Characterising the Scaling Properties of Incompressible Isotropic Three-Dimensional MHD Turbulence

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Recent improvements in the scale and accuracy of direct numerical simulations (DNS) of three-dimensional incompressible isotropic MHD turbulence enable many of its fundamental properties to be investigated anew. Here we report progress on several questions, achieved using the DNS of Biskamp and Müller [Phys. Plasmas **7**, 4889 (2000)]. This employs the incompressible resistive MHD equations to simulate decaying isotropic turbulence, with finite magnetic helicity and initially equal magnetic and kinetic energy densities. It has a spatial resolution of 512^3 Fourier modes.

A central question is the nature (including dimensionality) of the localised turbulent structures that give rise to intermittency in the local rate of dissipation, and the relation of their role to that of less strongly dissipative but more widely distributed turbulent structures. In parallel, there is the question of the extent and nature of any universal scaling properties of the turbulent fluctuations.

Here we report progress based on analysis of the variation with distance of differences in the Elsässer field variables $z^{\pm} = E \pm B$, and of dissipation rates. The scaling of the local rate of dissipation (both viscous and Ohmic), and of its one-dimensional surrogate, are compared with the picture gained from the study of the Elsässer field variables. Intermittency in these measures is analysed in the framework of the generalised theory of the intermittency correction proposed by She and Leveque [Phys. Rev. Lett. **72**, 336 (1994)]. A range of techniques is used to characterise any universal scaling behaviour that arises from the relatively low Reynolds number flows obtainable by DNS. These include extended self-similarity (ESS), which extends a variant of inertial range scaling into the dissipative range. ESS assumes that within the dissipative range, the energy flux through length scale (l) varies with l in the same way for structure functions of all orders, so that $\langle \delta z^{(\pm)p} \rangle \propto \langle \delta z^{(\pm)q} \rangle^{\zeta_q/\zeta_p}$ where $\langle \delta z^{(\pm)} \rangle = \langle |z(\mathbf{x},t) - z(\mathbf{x},t)| \rangle$ and $\langle \delta z^{(\pm)p} \rangle \propto l^{\zeta_q}$. This allows the ratio of scaling exponents (ζ_q/ζ_p) to be accurately determined, since scaling is extended into the dissipation range.